2. WHY CACTI ?

Most of the inquisitive visitors to this Botanical Garden generally ask "What is special about Cacti and Succulents", and "Why a Botanical Garden of Cacti and Succulents only?"

For an answer to these questions one has to look into the evolution of Life on Planet Earth. Eons ago in its earliest life span, vast areas of this planet were covered with water, there were oceans and marshlands only. Flora of that period, as revealed by fossils, was broad-leaved plants such as bananas. During the subsequent evolutionary upheavals over millions of years, more land masses were created, due to eruption of volcanoes or other natural phenomena. Mountains, plains and deserts came into existence. There were now long periods of drought and non-availability or shortage of moisture during which a large number of floras perished. It was a constant phenomenon of survival of the fittest.

MR. GORDON ROWLEY, the doyen of present-day succulent scientists, explained this very nicely as follows, in a contribution to our

magazine, the JOURNAL OF NATIONAL CACTUS AND SUCCULENT SOCIETY OF INDIA, volume IV, 1984, pp. 48 -51.

"The overall appearance of a plant---its "life-form"---is conditioned by the environment in which it grows. In a highly competitive world everything that does not function to perfection is eliminated in the course of evolution. What we see today are the end products of the millennia of selection and adaptation. The factor that has moulded appearances most drastically is the periodic absence of water. Survival depends upon being able to tide over long periods of drought. There is no one ideal method. Innumerable different strategies have been tried, each depending upon a combination of basic ingredients: storage of water in swollen tissues, reduction of evaporating surfaces, ability to go dormant by shedding leaves or branches or retreating underground, closing of stomata, especially during hottest hours of the day, and so on. What is so remarkable is that in the course of evolution quite unrelated plants have often come up with the same life-form combining the same drought-combating or drought-evading features. Thus, we find landscape of, say, Arizona, looks superficially like that of Africa and Madagascar where the climate is similar. The plants, however, belong to different genera or families. Carnegia *is replaced by*

tree Euphorbias *or* Pachypodiums*;* Agave *by* Aloe*;* Ibervillea *by* Kedrostis *and so forth".* [The family, genus and species of each plant to be mentioned in this book will be found listed alphabetically in an index at the end.]

"It is possible to recognise a large number of distinct life-forms in succulents based upon changes in habit, morphology and function of parts. First we have the Leaf Succulents in which bulk of water storage is foliage. The thick, fleshy leaves are usually simple in outline rather than lobed or divided and are commonly crowded together or overlapped in a spiral to form a rosette".

"Stem Succulents, by contrast, store water in enlarged stems. (Roots can also be succulent, but this is rare and will not be considered further here). There are several contrasted patterns of stem succulence. Cacti*,* Stapelieae *and many shrubby or tree-like* Euphorbias *have much reduced leaves and cylindrical green stems which take over the function of photosynthesis. Often these have parallel ribs or tubercles arranged in regular spirals. Branching is usually in tiers, candelabras or hands (like a bunch of bananas), with constrictions at the point of branching so that the plant body is jointed. For convenience, the tall habit is called* Cereiform *(after* Cereus*)*

and the dwarf solitary or clustered habit Cactiform *(after* Cactus*, the old generic name for* Melocactus*)".*

"Another type of stem succulence is shown by Cyphostemma*,* Adenium*,* Tylecodon*, Mexican tree* Sedums *and certain large woody plants commonly referred to as bottle or barrel-trees. Here there are flat, mostly thin, expanded leaves, but they are confined to the stem tips and are deciduous for part of the year. The main stem is conical with a broad base, tapering gradually into thick branches which are not jointed, arranged in a regular pattern. Also they are not green (or only when young), but are covered in bark that may be irregularly corky or smooth and peeling. Regular ribs or tubercles are not typical of this life-form, which is referred to as* Pachycaul*."*

Succulent plants are found in 40-50 plant families and are found all over the world. One of the succulent families, "Cactaceae" evolved only in the American Continent and adjacent islands. One cactus species *Rhipsalis* is also found in Madagascar and Ceylon. It is generally believed that these habitats are the result of dispersal by birds or human beings. Cacti have adopted all life-forms described above except the leaf succulents. Only a

couple of species, such as *Pereskia* and *Pereskiopsis* have leaves. Leaves of the latter are succulent to some extent but those of *Pereskia* are thin. These leaves are dropped during dormancy. A few other species of cacti may have small rudimentary leaves in fresh growth but they are shed as the plant grows.

The name Cactus (plural Cacti) is derived from the Greek word "Kaktos" which means a spiny or prickly plant. No doubt, the Cacti generally have spines, but all plants bearing spines are not Cacti. The plants of "Cactus" family have some distinctive diagnostic organs not found in other plants. On their body they have small cushion like organs called *areoles.* They are generally small pads, with bristles or wool and one or more spines arising from them. The flowers vary in size and colour with an inferior ovary. Ovary has a single chamber. The fruit is a pulpy single chambered berry. The seeds have two cotyledons. The presence of areoles is the most distinctive single diagnostic factor for cacti. In some Cacti such as *Epiphyllums,* the thin leaf-like stem is often confused with leaves by the common growers.

There is a vast variation in life-forms of different Cacti and other Succulents. The botanists have never agreed on the exact number of Cactus and other succulent species. The Cactus species alone are considered to be about 3,000 to 6,000 by different botanists, besides the other succulent species that are believed to be thrice as many. With such a large number of species, with different shape and forms, the choice for the grower is unlimited. No modern sculptor or artist could create such beautiful forms. Due to their beauty, the temptation of the growers and that of the collectors of these plants has no limits. Greedy nurserymen have stripped clean cacti and succulents from vast areas of their natural habitat. There are stringent laws and penalties for the offenders, but the loot goes on. The development of virgin land for farming, and urban growth, has added to the peril of extinction of many of the species. The fate of Indian Succulents is no better. Most of the cacti and other succulents are already endangered, and some are extinct in their habitats. Even the most popular yet common "Golden Barrel Cactus", had practically disappeared from its natural habitat. Now with the help of conservationists and Botanical Gardens all over the world, these plants are being reintroduced again into their natural habitats.

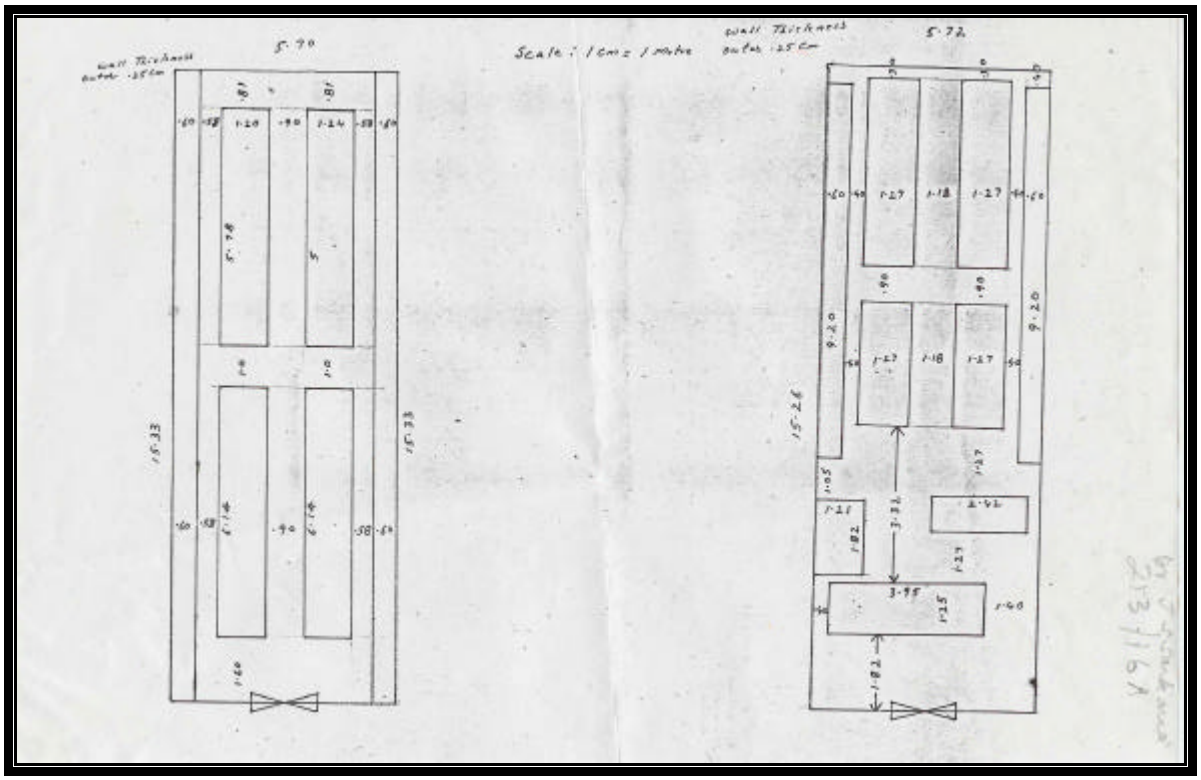
This Botanical Garden has been developed with the main objective of conservation and propagation of these endangered plants. The main thrust is towards collection and propagation of Indian Succulents. Already a good headway has been made in the conservation of the *Indian Carallumas*. These species are highly endangered. Now these are being propagated in this garden and due to our sustained efforts are getting acclimatised here.

3. PROPAGATION OF CACTI AND OTHER SUCCULENTS

When the Garden was started the biggest challenge was how to fulfill the need for thousands of Cacti and other succulents required. Very early in my career as a neo-cactophile, during a visit to the United States, MR. KIRKPATRICK, a respected and very experienced nurseryman, had given me some sane advice. He told me that if I wanted to build a good collection of Cacti and other Succulents, I should learn how to grow them from seeds, and by using other propagation techniques. He told me that it is practically impossible to buy a good collection. This sane advice from an experienced grower was fresh in my mind. While planning this garden, the creation of a good and extensive propagation centre was the first priority.

PROPAGATION AREA. This is situated in the north-east corner and hedged off from the rest of the garden. It comprises of two large propagation houses each 17 x 7 meters, two small houses each 7 x 6 meters, and eight propagation beds each 10 x 1.75 meters. It was planned that at first Cacti and Succulents will be propagated in the two large propagation houses, and later, when the plants are of adequate size, they will be grown and acclimatized outside in the propagation beds before going to their

permanent location on the garden features. One of the smaller houses serves as a sales outlet for surplus plants, and the other for sundry purposes, such as a sick-bay for damaged plants.



The interior layout of the big propagation houses shows shelves along their walls. The one on the left has four long raised propagation beds. The one on the right, which was built first, has four more, a work table, and, towards its upper right, the long seedling trough denoted by D in the text.

The two large propagation houses were the first to come up. Their structure has a low one meter high masonry wall on the sides. The space above the wall, up to the roof level, has strong wire mesh. The wire mesh is covered with strong, 2 meter wide, woven translucent plastic sheets. These keep out the winter cold and the hot dry summer winds, providing adequate

humidity and weather protection to the plants inside. The houses have translucent fibre-glass sheet roof. One of these houses is used for the propagation of cacti, while in the other both cacti and succulents are grown. The interior of these houses is planned in such a manner so as to utilize maximum space for growing plants. The shelves along the length of the two houses are for early propagated potted plants.

Propagation House 1.

The propagation of cacti and succulents subdivides into:

A. Growing from seeds.

B. Vegetative propagation.

GROWING FROM SEEDS. This is most important for introducing the maximum number of species. Good, field-collected seeds are easily available from seed suppliers in the U.S.A. and other countries.

Technique. The ideal method would be to grow the seeds in a proper propagation house or chamber. The ideal temperature range for most of the seeds is between 20^{O}-30^{O} Centigrade with 30-40 % of humidity for young seedlings. Adequate light is also necessary. In this garden we *don't* have any propagation chamber; instead we have tried to create most favourable conditions when the ambient atmospheric temperature is in the required range. The seedling trough number D in the 1st propagation house has a covering of a polythene frame with four to eight 50 watts electric bulbs fitted in the frame. The bulbs provide the necessary light and warmth for the germination and growth of seedlings.

Seedling Trough D

Baggy Method of Seed Germination. In the absence of a proper propagation chamber we are using what is commonly known as the "Baggy Method".

Containers. Small new earthen pots, or 15 to 30 cm square earthen trays, about 10 cm deep, are used. Old pots should be avoided, and in case they have to be used, must be thoroughly cleaned and heat-sterilized, either by boiling water or in an autoclave.

Soil Mixture. We are using a highly porous soil mixture. Very coarse fresh river-bed sand is used. Clay or fine dust is removed by using a fine mesh sieve having 60 holes to a square inch. Humus is provided by adding 30% coco-peat or fine spongy leaf mould. Very small quantity of bone meal is added. Previously we used to heat-sterilize this mixture before use. Now since the use of coco-peat, we have discontinued this practice. The pots or trays used get a 2 cm layer of coarse grit at the bottom, and are then filled up with the soil mixture to about 1 cm below the brim. The filled container is placed in a tray of warm water to which a fungicide is added. We are using BAVISTAN, 2 grammes per litre of water. When the pots are completely soaked, they are taken out, and excess water thoroughly drained. This may take 10 to 20 minutes.

The seeds are sprinkled on the top of the soil. Most of the seeds need no further soil cover. Very large seeds are covered with a little soil mixture sprinkling. The pots are now enclosed in new clear polythene bags and the mouths are closed with a tie. The bagged containers are placed in the propagation trough D in house number I. An appropriate number of lights is switched on to give the necessary temperature. Seed germination usually takes place within a few days, but some may take a much longer time---maybe a few weeks.

The bed across seedling trough in Propagation House 1

In the days following the bagging, care is taken to see that there is no excess moisture inside the bag. If there is, the bag mouth is opened for a couple of days and any excess water accumulation at the bottom is also drained. Care is taken to see that the seed compost is not too wet. At the same time it should not be allowed to dry out. This method is very effective. Seedlings being grown in this trough are generally removed from the bags after 2-3 months. Thereafter, to keep the soil constantly moist, the trough is filled up to 3 to 5 cm depth with water. This keeps the pots moist, but not too wet. The seedlings are allowed to grow as long as there is no overcrowding. When the seedlings are two to three cm. in size, they are planted in the long raised propagation bed right across the aisle from the seedling trough D in the very same propagation house. Here they grow for another year, and thereafter they are transferred to propagation beds outside. The propagation beds are protected with polythene-covered frames. In these beds they continue to flourish. A low dose of an inorganic fertilizer is given at monthly intervals during their active growing season. The plants remain in these beds till they are required on the display mounds of the garden. Surplus plants, if any, are put up for sale in one of the smaller houses.

Showing four of the outdoors propagation beds

The two smaller houses in the propagation area

PERESKIOPSIS GRAFTING OF SEEDLINGS. To hasten normal seedling growth, which is very slow, a grafting technique is used with *Pereskiopsis velutina* stock. The ideal ambient conditions are 25° to 35° C outside temperature, with over 30% humidity. The technique is very simple. Four to five centimeters long terminal cuttings of *Pereskiopsis* are set to root in sand, in 10 cm pots, but not more than three to four cuttings in one pot. Under ideal conditions, these cuttings root very easily and are ready for grafting in three to four weeks, with vigorous fresh growth. Seedlings four to five months old and about two mm in diameter can be easily grafted. The stock is sectioned transversely through the succulent growth. It may necessary to remove the upper two or three leaves.

Periskiopsis grafting.

The section is made with a sharp, preferably a new shaving blade. After the section sap oozes out from the cut surface, a second cut is made below the first, thus making a very thin slice. This slice is allowed to remain in place till the seedling scion is ready. The seedling is now taken from its pot using a fine forceps. The small roots of the seedling are held gently between the thumb and the forefinger of the left hand, and the body of the seedling is cut horizontally. The sectioned seedling top, i.e., the *scion*, now lies on the blade. [For the rarer seedlings, we do not waste the sectioned seedling's bottom: it too is grafted—this time upside down!---on another stock in an analogous way, often yielding new offsets.] The thin slice on the sectioned *Pereskiopsis* stock is removed, and the seedling scion is carefully slid onto the stock.. For the success of the graft it is very essential that the scion and the stock vascular bundle must cross each other (that is, the circular patterns in the two should overlap as shown in the diagram above). Very slight finger pressure on the seedling scion, for a minute or so, causes firm adhesion of the two. Sometimes, with larger seedlings, we apply pressure with a glass-slide for a couple of hours. The freshly grafted plants are placed in a location where the temperature and humidity are appropriate. Under ideal conditions we have a success rate of above 90%. The grafted seedling grows fast and in most cases may be 3 to 5 cm in diameter within

six months. Now it may be allowed to grow further on this stock or is grafted on a thicker stock. At times when the *Pereskiopsis* stock is not too long, we bury the entire stock in the soil. Over a couple of years the stock takes the function of the tap root of the new plant. One can get a good sized plant in a relatively shorter period. In my collection I have a large grouping plant of *Aztekium ritteri*, on *Pereskiopsis* graft, filling a 10 cm. pot in about 10 years. Another field collected *Aztekium ritteri* plant, over 40 years old is less than one-fourths the size of the grafted plant. Recent re-potting of the grafted plant showed vigorous root growth and one could hardly identify the original stock.

VEGETATIVE PROPAGATION. These techniques play a very important role in increasing the number of larger-sized plants in a comparatively shorter duration. Several techniques are used.

In cacti, the following two techniques are the most prevalent.

1. Propagation from cuttings and offsets.
2. Grafting on robustly growing stock .

In other succulents, vegetative propagation is done by:

1. Rooting stem cuttings and offsets.
2. Grafting on stock.
3. Leaf cuttings.
4. Tissue culture.

Propagation of Cacti from cuttings and offsets. Cacti cuttings are taken through the fleshy part of the cactus body. The inner vascular bundle of the cactus cuttings must not be woody. Cuts are preferably made at the joints. The cut surface is tapered by cutting the thick epidermis obliquely. The cut is dusted with fungicide. Rooting hormone with fungicide may be used. The cuttings are placed in a shady, airy place to dry out or *callus* (development of hardened tissue over a wound) as it is technically termed. Offsets and cuttings through the joints have small raw areas and callus in a few days. Large raw areas may take several weeks or months to callus. When properly callused, the cutting is placed on a sandy loam or coarse sand in a pot or container. It may be pushed into the sand for one centimeter or so, but never very deep. When the cut shows new growth, light watering, twice a week is started. Offset cuttings generally root very rapidly.

Propagation of Cacti by Grafting. Grafting of seedlings has already been described in detail. Grafting of cactus cuttings and offsets is also a simple procedure. Several species of *Cerei* have been tried as stock – *Cereus peruvianus, Acanthocereus pentagonus, Hylocereus* species, *Mytrillocactus geometrizans* and *Ritterocereus pruinosis* have been used in the past. Nowadays, most of our grafting is on *Ritterocereus pruinosis,* and occasionally on *Mytrillocactus geometrizans* and *Hylocereus* species. The other *Cerei* are not useful in the long run. They are not winter hardy and if surviving, become woody in 2-3 years. *Ritterocereus pruinosis* has a very strong root system and the growth of the scion is very vigorous, and in the case of offsetting cacti, good sized groups are formed in two to three years. When planning to create large groups of *Mammillarias,* low grafting technique is used. Stock height is limited to 5 to 8 cm length or so. As the group forms, the stock is covered with loam. Very quickly the offsets of the groups develop strong root system accelerating the growth further. Very large groups of *Mammillaria* have been mostly created in 8-10 years by this method. Normally, on their own roots, they take twice that much time.

Grafting Technique. The rooted stock is potted in the smallest possible pot. Most of the grafting is done by the horizontal cut method. The

stock is sectioned through its new growth area horizontally. The epidermis is cut obliquely (see bottom part of diagram above). A second cut is made to create a very thin slice on the top. The scion, which may be an offset, or a healthy top [sometimes even the bottom half is put to use as an upside-down graft] cut of a cactus, is again sectioned neatly. The edges are bevelled obliquely. The slice on top of the stock is removed, and the scion slid onto the stock. The vascular bundles of the stock and the scion must be aligned optimally (that is, with their circular patterns overlapping as in diagram). The scion is firmly pressed with finger to remove excess sap or air. After this the graft is held in place by a couple of rubber bands or tied in place by knitting wool or any other elastic material. The grafted plants are placed in a shady, airy area on a bench. While watering, care must be taken that this new graft is not soaked with water, otherwise it may rot. In our glasshouse we carry out grafting for most of the year except during the winter months. In addition to the horizontal cut method, occasional recourse is taken to wedge grafting technique. This is quite analogous to the method used in grafting fruit-trees, the only difference being that the V-shaped receptacle wedge is now made not on the side, but on the top of the stock, and then the compatibly tapered end of the graft is slid into this wedge.

Propagation Technique in Succulents Other Than Cacti:

Rooting of cuttings is extensively applied in succulents. Again, preferably the cuts must be made just beyond a joint. This is a must in *Euphorbias.* Cuts made in the body of a *Euphorbia* leave a large loosely spongy area which does not callus easily. *Rooting of offsets* is the most effective method in small growing *Aloe*s, *Haworthias, Gasterias* and a large number of other succulent species. The raw area of the offset generally calluses within 4 to 7 days and then can be easily potted.

Grafting techniques, mostly wedge-grafting, can be used successfully, but only amongst succulents belonging to the same botanical family. *Adenium* and *Pachypodiums* are being grafted extensively in this garden, and wedge grafting method is used.

From Leaf Cuttings. In most of the Succulents with fleshy leaves, leaf cuttings root easily. While removing the leaf, care is taken to take dormant bud, at the site of its attachment with the stem, along with the leaf. This method is extensively used in *Crassulaceae* Family and *Haworthias. Gasterias* are also propagated by this technique. A highly succulent

Gasteria leaf cut even across its middle roots successfully. However, *Aloe* leaves cannot be rooted.

Tissue Culture. In several countries, tissue culture of succulents, for example, of rare *Haworthias* and some other species, is now being extensively used.